REMARKS

The Office Action rejects claims 1,7,9,11,12,16 and 18 under 35 U.S.C. 102(b) as being anticipated by Ho et al.

Applicants have amended claim 1 to more clearly distinguish over the Ho reference. Claim 1, as amended, is drawn to a semiconductor device, which includes a semiconductor die. A semiconductor package is made with a thermally conductive overmolding compound containing an epoxy filler and granules which enhance thermal conductivity of the overmolding compound to a value greater than 2 watts/meter K. The thermally conductive overmolding compound physically contacts the semiconductor die to directly transfer heat generated by the semiconductor die through the thermally conductive overmolding compound. A pin-fin heat sink is mounted to substantially an entire surface area of the semiconductor package. The heat generated by the semiconductor die is dissipated through the thermally conductive overmolding compound to the pin-fin heat sink.

The Ho reference does not teach or suggest the use of a thermally conductive overmolding compound containing an epoxy filler and granules which enhance thermal conductivity of the overmolding compound to a value greater than 2 watts/meter K. In addition, the Ho reference does not teach the thermally conductive overmolding compound coming into physical contact with the semiconductor die. Instead, Ho teaches an encapsulant which only comes into contact with IC chip 230, but not the internal semiconductor die (See, e.g., FIG. 7). The semiconductor die is located within the IC chip package 230.

The Ho reference does not seek to utilize the enhanced thermal conductivity of the encapsulant to improve cooling. Ho

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makes no reference as to the thermal conductivity of the encapsulant (mold compound) other than to state that its inherent thermal resistance is too high. Instead of relying on the thermal conductivity properties of the encapsulate material to facilitate more efficient thermal transfer, Ho seeks ways to reduce the cross-sectional thickness of the encapsulant.

Ho teaches away from reliance on thermal conductivity properties of the encapsulant material. Instead, Ho relies on the placement of a "thermally-conductive piece" (see, e.g., 200 in FIG. 1) to channel thermal energy away from the IC chip. Based on a reading of the specification it can be inferred that the thermal conductivity of the surrounding encapsulate material is intended to be much less than that of the thermally-conducting piece 200. In fact, Ho states:

> "[i]f a higher heat-dissipation efficiency is desired, the thickness C1 of the thermally-conductive piece 200 can be increased as large as it would not make the thermally conductive piece 200 to come into contact with the gold wires 250 or the top surface of the IC chip 230. This can effectively reduce the heat path B1 from the IC chip 230 to the thermally-conductive piece 200, so that the heat produced by the IC chip 230 during operation can be conducted to the thermally-conductive piece 200 more quickly" (see Col. 5, lines 13-21).

The Ho reference also does not teach or suggest mounting of a pin-fin heat sink to substantially an entire surface area of the semiconductor package. Rather than attaching an external heat sink to the entire top surface of the BGA package, Ho teaches a depression into the top surface into which a heat sink

is placed in closer proximity to the heat source. The benefits of this method are somewhat misrepresented by the illustrations. In the cross-sectional drawings of the BGA packages, the packages appear disproportionately thick to accentuate to the benefit of the disclosure. The drawings and specification serve to reinforce the notion that Ho is concerned about variations in thickness of the encapsulant and proximity to a heat generating source, rather than the properties of the encapsulant material itself.

In contrast, Applicants' present application focuses on using the physical thermal conductivity properties associated with various selected epoxies and materials to enhance thermal transfer and thereby remove heat from the semiconductor die. The thermally conductive overmolding compound makes direct physical contact with and surrounds the semiconductor die. The thermally conductive overmolding compound contains an epoxy filler and granules which enhance thermal conductivity of the overmolding compound to a value greater than 2 watts/meter K. In one example, the enhancing granules are aluminum oxide or crystalline silica. Heat generated from the semiconductor die is directly transferred to the thermally conductive overmolding compound. Heat is then directly transferred through a surface of the thermally conductive overmolding compound to a mounted pin-fin heat sink.

Claim 1, as amended, is believed to patentably distinguish over the Ho reference. Applicants have canceled claims 3 and 4. Claims 2 and 5-10 are believed to be in condition for allowance as each is dependent from an allowable base claim.

Applicants have amended claim 11 to more clearly distinguish over the Ho reference. Claim 11, as amended, is

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drawn to a semiconductor device, which includes a heat generating semiconductor die. A thermally conductive encapsulate contains granules within an epoxy filler to provide a thermal conductivity greater than 2 watts/meter K. The thermally conductive encapsulate physically contacts a surface of the semiconductor die to distribute heat generated by the semiconductor die through the thermally conductive encapsulate. A heat sink is disposed over substantially an entire surface of the thermally conductive encapsulate for dissipating the heat generated by the semiconductor die.

Ho does not teach a thermally conductive encapsulate containing granules with an epoxy filler to provide a thermal conductivity greater than 2 watts/meter K. Additionally, Ho does not teach or suggest that the thermally conductive encapsulate physically contacts a surface of the semiconductor die to distribute heat generated by the semiconductor die through the thermally conductive encapsulate. Finally, Ho does not teach or suggest a heat sink disposed over substantially an entire surface of the thermally conductive encapsulate for dissipating the heat generated by the semiconductor die.

For these reasons and the reasons previously identified, Applicants believe amended claim 11 patentably distinguishes over the Ho reference. Applicants have cancelled claims 14 and 15. Claims 12-13 and 16-19 are believed to be in condition for allowance as each is dependent from an allowable base claim.

Claims 1 and 11, as amended, are also believed to overcome a possible obviousness rejection under 35 U.S.C. 103(a). Per the examiner's remarks, Ho does not teach a structure which includes a thermally conductive overmolding compound containing an epoxy with the above-identified properties. Amended claim 1

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and 11 serve to better highlight the stark differences between a combined Ho reference/Yamashita reference and the present invention.

In determining the differences between the prior art and the claims, the question under 35 U.S.C. 103 is not whether the differences themselves would have been obvious, but whether the claimed invention as a whole would have been obvious. *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 218 USPQ 871 (Fed. Cir. 1983); *Schenck v. Nortron Corp.*, 713 F.2d 782, 218 USPQ 698 (Fed. Cir. 1983). In light of the foregoing, Applicants respectfully suggest that the claimed invention, taken as a whole, is much too different than the combined Ho/Yamashita references to render the instant invention obvious under 103. In other words, the Yamashita reference, literally combined with the Ho reference, renders a completely different result than the instant invention.

The Yamashita reference does not teach a semiconductor die directly and physically contacting and encapsulating a thermally conductive overmolding compound. FIGs. 7A and 7B show an integrated circuit 702 with accompanying lead frame mounted to a top surface of a PCB or wiring substrate 703. The thermally conductive epoxy 704 does not encapsulate the semiconductor die, but rather, the BGA package. To further illustrate, IC 511 as part of a BGA assembly is shown coupled to a wiring substrate 503 in FIG. 5B. A "resin" 511 encapsulates the IC 511. Resin 511 does not physically contact and encapsulate the semiconductor die of IC 511.

Moreover, resin 511 is intended to mainly provide structural support. The heat generating surface of IC 511 makes direct physical contact with heat spreader 512. Heat spreader

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512 is intended to perform the heat displacement function, not necessarily resin 511. Resin 511 is not specifically identified as a "thermally conductive and electrically insulating member" as 704 shown in FIG. 7B.

To establish prima facie obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). "All words in a claim must be considered in judging the patentability of that claim against the prior art." *In re Wilson*, 424 F.2d 1382, 1385, 165 USPQ 494, 496 (CCPA 1970). If an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988).

In light of the foregoing, Applicants respectfully suggest that the combination of Ho et al. with Yamashita et al. does not teach or suggest all the claim limitations of amended claims 1 and 11. Since Yamashita fails to teach or suggest the use of a thermally conductive overmolding compound which directly and physically contacts and encapsulates a semiconductor die, claims 1 and 11 as amended are believed to patentably distinguish over the prior art references, taken singularly or in combination.

The Office Action rejects claims 2-4 and 13-15 under 35 U.S.C. 103(a) as being unpatentable over Ho in view of Yamashita et al. Applicants have canceled claims 3-4 and 14-15. Claims 2 and 13 are believed to be in condition for allowance as each is dependent from an allowable base claim.

The Office Action rejects claims 5 and 6 under 35 U.S.C. 103(a) as being unpatentable over Ho in view of Mostafazadeh et al. Claims 5 and 6 are believed to be in condition for allowance as each is dependent from an allowable base claim.

The Office Action rejects claims 8 and 17 under 35 U.S.C. 103(a) as being unpatentable over Ho in view of Huang et al. Claims 8 and 17 are believed to be in condition for allowance as each is dependent from an allowable base claim.

The Office Action rejects claims 10 and 19 under 35 U.S.C. 103(a) as being unpatentable over Ho in view of Davies et al. Claims 10 and 19 are believed to be in condition for allowance as each is dependent from an allowable base claim.

Applicants believe that all information and requirements for the application have been provided to the USPTO. If there are matters that can be discussed by telephone to further the prosecution of the Application, Applicants invite the Examiner to call the undersigned attorney at the Examiner's convenience.

The Commissioner is hereby authorized to charge any fees due with this Response to U.S. PTO Account No. 17-0055.

Respectfully submitted,
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